

OBITUARY

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Yakov Petrovich Terletskii

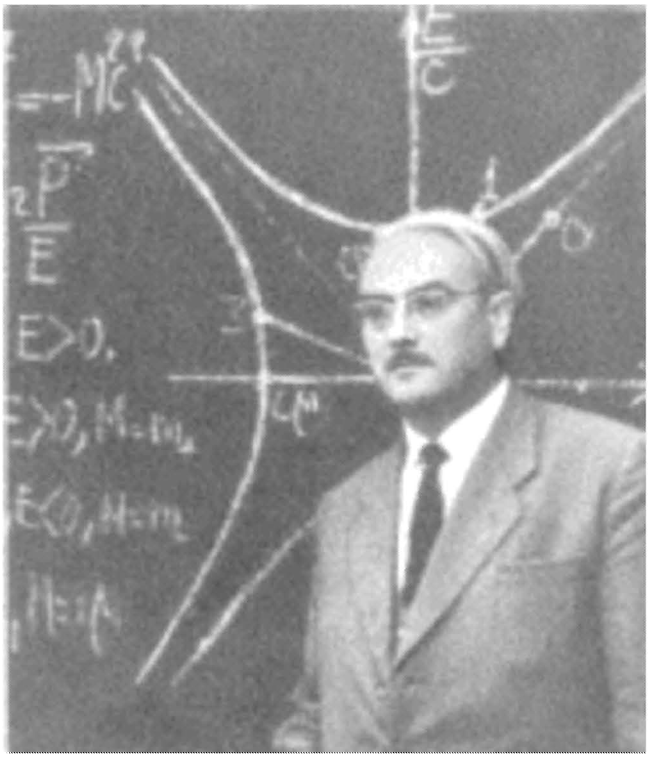
Professor Yakov Petrovich Terletskii, one of the outstanding Russian physicists, Honoured Scientific Worker of the RSFSR (Russian Soviet Federal Socialist Republic), laureate of the Lenin and State Prizes and of the Lomonosov Prize from Moscow State University, Member of the Swedish Royal Scientific Society (Uppsala), and Doctor of Physical Mathematical Sciences, died suddenly on 15th November, 1993 at the age of 82.

Terletskii was born in Petrograd on 30th June 1912 in a family of state school teachers. In 1930 he completed the L B Krasin special electrotechnical course and worked as an electrician at the Moscow electric lamp factory.

Passion for physics led Terletskii in 1931 to the Faculty of Physics of Moscow State University. The lectures by Professor K V Nikol'skii and Academician L I Mandel'shtam and the works of L Boltzmann, S A Boguslavskii, and others have had the greatest influence on Terletskii's education as a theoretical physicist.

After graduating from Moscow State University in 1936, Terletskii carried out his first scientific study on ''The limiting transition from quantum to classical mechanics'' under the supervision of Leonid Isaakovich Mandel'shtam (*Zh. Eksp. Teor. Fiz.*, Vol. 7, 1937). In this study, Terletskii introduced a special quantum distribution function in a mixed coordinate – momentum representation, which was subsequently called the 'Terletskii function'. It was found that the Terletskii function satisfies the evolution rate equation which leads to the Liouville equation in the limit $\hbar \to 0$. It was later demonstrated that the method of quantum distribution functions, initiated with the familiar study of E Wigner in 1932, is the most logical and natural for the establishment of a correspondence between quantum and classical statistical mechanics. Subsequently Terletskii's ideas on these lines were developed and extended by his pupils: V V Kuryshkin, Yu I Zaparovannyi, and others. This led to the formulation of quantum mechanics on the basis of a nonnegative distribution function within the framework of which non-Neumann correspondence rules were demonstrated and apparently the necessity for using distorted commutation relations — constituting the basis of quantum algebras and groups, which became popular subsequently — was noted for the first time.

After graduating from the Faculty of Physics of Moscow State University, Terletskii remained as a postgraduate in the Department of Theoretical Physics,



Yakov Petrovich Terletskii
(1912 – 1993)

where he began his studies under the supervision of Professor I E Tamm and completed them under the supervision of Professor M A Leontovich.

He continued to be concerned with problems of statistical quantum mechanics and in 1939 he generalised the theorem stating that a classical explanation of magnet-ism is impossible (the Bohr – Van Leeuven – Terletskii theorem). In the same year, Terletskii defended his Candidate's dissertation on ''The hydrodynamic theory of Brownian motion'' and became an Assistant in the Department of Theoretical Physics at Moscow State University, with which he remained associated for more than thirty years.

In 1939 – 1941 and in subsequent years, Terletskii devoted much attention to problems of technical physics, in particular to the development of the theory of electron beam generators. Thus in 1941, together with S Gvozdover and L Loshakov as coauthors, he published a short communication in *Doklady Akademii Nauk SSSR* (Vol. 30, p. 608), which has since become a classic and is frequently quoted in the literature. This became

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subsequently a distinctive feature of Terletskii's creative work. By virtue of his striking intuition, he formulated and solved problems in such a way that his innovative work frequently initiated the development of new lines of research. All this was remarkably combined with an extremely broad range of interests: from the abstractions of the physics of the microworld to the principles of the operation of specific radiophysical devices.

During the Second World War, Terletskii was occupied with the evacuation of the Faculty to the East. He worked in Kazan on the solution of problems concerned with defence. Nevertheless, he also found time for fundamental problems of statistical physics and in 1945 he defended his Doctoral dissertation on "Dynamic and statistical laws of physics", which was published in 1950 as a monograph. In his dissertation, Terletskii discusses the problems concerned with the justification of the statistical laws of physics, in particular, the quantum rules. He proposed a new weakened ergodic condition and showed that the majority of mechanical systems satisfy it. Postulates of the theory of nonequilibrium processes, which have led to a new approach to the statistical theory of fluctuations and Brownian motion, were formulated in the dissertation and the latter also contains the fundamental ideas of the method of functional integration in statistical physics. On this basis, Terletskii subsequently demonstrated — together with his pupils V B Magalinskii, V P Milant'ev, Nguyen Tang (Vietnam), and others — a series of important theorems of nonequilibrium statistical physics, which are also valid for systems with distributed parameters. In particular, the Onsager relations and the fluctuation–dissipation theorem were demonstrated in a more general form.

As early as 1941, Terletskii was interested in the problem of the motion of relativistic electrons in variable magnetic fields. In particular, in his communication "The relativistic problem of the motion of the electron in a variable parallel magnetic field with axial symmetry" (*Zh. Eksp. Teor. Fiz.*, Vol. 11, 1941) he applied for the first time the laws of relativistic dynamics to the construction of a theory and the design of the simplest induction electron accelerator — the betatron. Subsequently Terletskii carried out a series of studies on problems of the radial stability of the motion of electrons in axially symmetrical magnetic fields, i.e. essentially the first steps were taken towards the modern theory of cyclic accelerators. In particular, it was precisely in these investigations that Terletskii put forward the idea of a pulsed induction accelerator — the 'noniron betatron'. In 1948 Terletskii was awarded the Lomonosov Prize for a series of studies on the theory of the betatron.

Terletskii and his students frequently returned to this range of problems and tasks in subsequent years. Thus in 1958 Terletskii and M V Konyukov proposed a new principle of the acceleration of electrons — a linear betatron in which electrons should be accelerated by a travelling wave of the magnetic type. The theory of the linear betatron was established in the studies of Terletskii and Ts I Gutsunaev. Terletskii's ideas concerning the theory of accelerators led to his becoming passionately interested in the theory of the origin of cosmic rays. In particular, in an early study "The induction of streams of fast charged particles by rotating magnetised cosmic bodies" (*Dokl. Akad. Nauk SSSR*, Vol. 47, 1945) he put forward the hypothesis of the existence of rapidly rotating magnetic stars with giant electric eddy fields, which accelerate charged particles in interstellar space. On the basis of the proposed model of the stellar-induction accelerators, Terletskii predicted in 1948 the existence of an ionic component in primary cosmic rays. This component was soon discovered in the experiments of American scientists and the subsequent discovery of pulsars can be regarded as direct confirmation of Terletskii's hypothesis of the origin of cosmic rays.

Terletskii's ideas and studies in the field of the theory of induction accelerators and the physics of cosmic rays received wide recognition. He was honoured by the 2nd Degree Stalin† Prize in 1951 for this series of investigations.

A series of studies by Terletskii together with A A Logunov and Yu A Popov were devoted to problems of the origin of cosmic rays and the mechanism of the diffusional acceleration of charged particles in magnetised interstellar space. Here one should also include Terletskii's investigations (which have found astrophysical and other applications) of the magnetic hydrodynamics of a rarefied plasma in which the problem of the drift of particles in the magnetic field was studied. As a development of this aspect, V P Milant'ev (who was Terletskii's student) and his coworkers created the drift theory of the motion of charged particles in both quasistatic and high-frequency electromagnetic fields.

In 1952 Terletskii proposed a fundamentally new method for generating ultrastrong magnetic fields based on the familiar effect in which the lines of force are 'frozen' into a conducting medium‡. This effect is manifested on rapid (explosive) compression of conducting shells in a magnetic field (magnetic cumulation). Magnetic fields with a strength of tens of millions of oersteds and higher were subsequently generated in devices constructed on this principle. The magnetic cumulation effect is applicable to the construction of large-scale accelerators of elementary particles in order to attain ultrahigh energies. Although these are 'single use' accelerators, the cost of one pulse in these devices is significantly lower than in modern accelerators. Terletskii was awarded the Lenin Prize in 1972 for work in the field of magnetic cumulation.

When it was decided to establish a research centre in Dubna in the 1950s, Terletskii was invited to head the Division of Theoretical Physics and from 1952 till 1956 he successfully combined this activity with his main work as Professor at Moscow State University. This was also naturally reflected in the subject of his research, in which the physics of elementary particles began to occupy a significant place. Thus, as a development of the theory of multiple generation proposed by Fermi, Terletskii and V B Magalinskii first applied in 1957 the microcanonical Gibbs distribution in the calculation of the statistical weighting factors for a quantum system of particles generated in the collision of nucleons.

† This was later renamed the State Prize.

‡ Since this work was classified, it was published much later (*Zh. Eksp. Teor. Fiz.*, Vol. 32, 1957).

Terletskii was one of the first who drew attention, as early as the 1950s, to the very great possibilities of the nonlinear field theory for the description of the structure of elementary particles. Developing the ideas of Einstein and de Broglie concerning the use for this purpose of regular localised solutions of nonlinear field equations, Terletskii became actively engaged in the search for such solutions, which were subsequently called the soliton solutions. In particular, he initiated the application of the first computers to the numerical analysis of particle-like solutions in nonlinear models. The subsequent development of this subject by, among others, Terletskii's students F S Shushurin, M I Stakvilevicius, G N Shikin, Yu P Rybakov, and others, involving the study of problems of the existence, stability, and interaction of solitons, made a significant contribution to the establishment of the modern physics of solitons.

The hypothesis of the existence of exotic particles with negative and imaginary intrinsic masses occupies a special place in Terletskii's scientific work. The fact that their introduction into the theory is logically noncontradictory was thoroughly justified by Terletskii in 1960§. The interesting and far-reaching conclusions arising from this hypothesis soon engaged the interest of a broad scientific community: for example, the energy spectrum of cosmic rays and the helical structure of galaxies have been explained with its aid.

Among Terletskii's other achievements, mention should be made of his contribution to the development of the theory of large gravitational systems, for which he demonstrated that the probability of large fluctuations greatly increases under these conditions. This result, which is of great cosmogenic importance, permits a new approach to the problem of irreversibility. Since the end of the 1960s, Terletskii (jointly with V I Zubov) developed a new approach to the statistical theory of the crystalline state of matter, based on the use of the phase distribution function asymmetric relative to the transposition of particles. This made it possible to create an effective theory of highly anharmonic crystals.

Terletskii's fruitful scientific activity was always combined with vigorous teaching activity. For 23 years, Terletskii was Professor in the Faculty of Physics of Moscow State University and in 1963 was invited to organise the Department of Theoretical Physics at the People's Friendship University. This department became yet another of Terletskii's notable creations, in which a surprisingly creative atmosphere was established and good traditions of friendly relations with colleagues, students, and postgraduates were initiated. Students always occupied a special place in Terletskii's life: he shared generously with them not only his great knowledge but also his spiritual warmth. He exercised a truly fatherly care, helped their development in every way, and followed with interest their subsequent creative successes. Terletskii owned a small garden property at Sofrino in the vicinity of Moscow. During recent decades he considered it to be, as it were, 'departmental' and during the summer placed it at the complete disposal of one of his students entirely free of charge.

§Indepently of Terletskii and approximately at the same time, the hypothesis of the existence of ultralight particles — *tachyons* — was put forward by the Japanese physicist Tanaka.

The diploma works supervised by Terletskii were carried out in their time by the future academicians G I Budker and A D Sakharov (who later transferred to I E Tamm already as a postgraduate student). Terletskii's diploma and postgraduate students included Academicians A A Logunov and G M Garibyan. During his work at Moscow State University, in Dubna, and at the People's Friendship University, Terletskii trained directly 44 Candidates of Science, of whom 12 became Doctors of Science and Professors. Hundred of young scientists who passed through Terletskii's school at Moscow State University and at the People's Friendship University have been working successfully in more than 100 countries.

During his years as a lecturer, Terletskii delivered lecture courses on virtually all branches of theoretical physics. His monographs *Dynamic and Statistical Laws of Physics* and *Paradoxes of the Theory of Relativity* (this book was translated into English and Japanese) received wide recognition. Terletskii devoted much attention to the creation of textbooks on theoretical physics, which are very popular among students both in Russia and abroad. In particular, his textbook *Statistical Physics'* translated into English, Japanese, Spanish, and Polish, has had two editions. The book *Electrodynamics* written jointly with Yu P Rybakov, has also been published in a second edition. Furthermore, Terletskii's Course of Theoretical Physics includes the textbooks *Theoretical Mechanics* and *Quantum Mechanics* (written jointly with Yu P Rybakov).

Terletskii was able to meet outstanding scientists of our time: Niels Bohr, Louis de Broglie, Richard Feynman, N N Bogolyubov, and others, with the majority of whom he was subsequently engaged for many years in a creative friendship. For a number of years, Terletskii was Member of the Editorial Board of *Zhurnal Eksperimental'noi i Teoreticheskoi Fiziki* (Journal of Experimental and Theoretical Physics) and the journal *Voprosy Filosofii* (Problems of Philosophy). In 1971, Terletskii was elected ordinary member of the Swedish Royal Scientific Society in Uppsala. Terletskii's achievements have been recognised by the highest state awards — the order of Lenin and the order of the Red Banner of Labour.

In the memory of people who knew Terletskii, he will remain as a surprisingly modest, gentle, and deeply intelligent person, whose aims were all associated with science.

A A Beilinson, *A N Gordeev*, *Ts I Gutsunaev*, Yu I Zaparovannyi, *V G Kadyshevskii*, *A A Logunov*, *V B Magalinskii*, *M G Meshcheryakov*, *V P Milant'ev*, *Yu A Popov*, *V M Filippov*